Coastal Benthic Optical Properties (CoBOP) of Coral Reef Environments: Effects of Changes in the Spectral Quality and Quantity of the Underwater Light Field and Elevated Temperatures on Small Scale (0.01 to 0.1 m) Optical Properties of Corals

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LONG-TERM GOAL

My principal goal is to understand the mechanistic basis for changes in the flourescent signatures, both host and algal symbiont, of corals. Changes in the spectral quantity and quality of visible and ultraviolet radiation will have effects of the quantum yield of photosynthesis and affect the fluorescent signatures of the algal symbionts as will changes in the temperature of the surrounding seawater. Since the reef environment is very dynamic, the challenge is to understand what environmental factors are responsible for the the greatest variability in these fluorescent optical signatures at small to large scales and understand sufficiently to model them over spacte and time.

OBJECTIVES

The Coastal Benthic Optical Properties (CoBOP) project is directed at understanding the optical properties of coastal benthic communities in general, and in particular, coral reefs. Coral reef communities are coastal areas of high water transparency which make them ideal systems to study optical signatures originating from the benthos. The scientific objectives of my project are:

1. to attain optical closure for coral reef communities

2. to understand the causes of benthic optical variability

   a. determine the spectral signatures of reef organisms

   b. determine the effects of the physical environment on the physiology of reef organisms and assess those effects on optical signatures

   c. identify the temporal and spatial scales of variability in these optical signatures

   d. to help evaluate the use of underwater systems to quantitatively measure fluorescent optical signatures

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APPROACH

Studies were conducted in May/June 1998 on Lee Stocking Island (LSI), Bahamas at 17 m depth. During this field season I was able to obtain measurements of photosynthesis and fluorescence, as well as samples for pigment analyses, on several species of corals including two dominant species of reef forming corals (*Montastraea faveolata* and *Montastrea cavernosa*). I have a close working association with Dr. Charlie Mazel on this project and we collaborated on obtaining reflectance and fluorescence spectra on corals *in situ* and from laboratory experiments and the characterization of the fluorescent chromophores. I also obtained data on ambient and underwater visble and ultraviolet radition to characterize the underwater light field (APO's) and help with optical closure experiments conducted around LSI, and the charcterization of the benthic coral reef community using photographic quadrat techniques. Lastly, I am also collaborated with Dr. Paul Falkowski on chlorophyll flourescent signatures using *in situ* Fast Repitition Rate Fluorometery (FRRF) on corals.

WORK COMPLETED

In the first year of this proposal the CoBOP program was able to establish its long-term research site on Lee Stocking Island in the Bahamas and conduct it's first field campaign. The second version of the underwater fast-repition rate fluorometer was tested during this time at LSI and proved to be highly successful (see below). Most of the FRRF data has been analyzed and will be compared to *in situ* rates of photosyntheis measured on corals from around LSI. Pigment analysis and other laboratory proceduress are still being carried out on the bulk of the material collected on LSI during the Spring 1998 field season. Lastly I will be providing data to be incorporated into a model of the optical properties of the coral polyp with the help of Dr. Robert Maffione, and reflectance data for Dr. Bill Philpot to incorporate into his remote sensing models.

RESULTS

The original underwater FRRF, although able to obtain usable results when tested in the Bahamas, proved to be cumbersome underwater. After providing this information to Dr. Paul Falkowski and his staff it lead to design improvements incorporated into the FRRF used during the Spring 1998 cruise to the Bahamas. During the two weeks of this project I was able to acomplish several important scientific tasks. First, a complete set of FRRF data was collected for the hermatypic coral, *Montastraea faveolata* over a significant portion of its bathymetric distribution; 3-4 m from Rainbow Gradens, 10 m from Horsehoe Reef, 12 m from North Perry, 17 m from North Perry, and 23 m from Bock Wall. For corals from the deeper portion of N. Perry we have long-term diurnal data. From Horsehsoe Reef we have similar data and representative corals from this population were used in a bleaching experiment in the sewater tables at CMRC. Lastly, Dr.Robert Rowan and myself conducted a comparison of FRRF and PAM measurements on corals that were bleaching and not-bleached at Rainbow Gradens as a result of an intrusion of Bahama Bank seawater with a temperature signal upwards of 32°C.

First, corals exhibit a repeatable diurnal pattern for the quantum yield of fluorescence of PSII (F_v/F_m). Mid-day depressions, most likely representing non-photochemical quenching, were evident in *M. faveolata*, and other species of coral. Secondly, FRRF can be used to predict bleaching. During an experiment in the sea tables at LSI a significant depression in F_v/F_m was observed 3-5 days before visible signs (*e.g.* colony paling) were observed. Lastly, significant differences were observed between colonies at Rainbow Gardens that were not bleached and those that were visibly paler and bleaching.

Dr. Rowan and I have taken samples from these colonies and Dr. Rowan will process these samples with the hypothesis that zooxanthellae from non-bleached colonies will be represented by clade A zooxanthellae, a species more resistant to temperature stress.

IMPACT/APPLICATIONS

Two specific impacts of the work completed to date are the refinement of the underwater FRRF for obtaining fluorescent signatures *in situ* and using this instrumentation as a tool to detect whether corals have been exposed to environmental stress that might lead to bleaching or mortality. The data set collected during the Spring of 1998 will be incorporated into two optical models; one small scale model of the optical properties of coral plyps and a second remote sensing model incorporating relfectance and pigment data from corals around LSI.

TRANSITIONS

The data collected from the 1995 and 1996 field seasons is presently in review for he journal Limnology and Oceanography. Information from our first field season of the present awardwill be used to improve instrumentation that will be used in the next 2-3 years in the field. Additionally, a small subset of the CoBOP group will conduct another field campaign on LSI this January to look at seasonal differences in the optical propertie of the water column at our LSI field sites.

RELATED PROJECTS

Charlie Mazel-ONR, CoBOP
Chalie Yentsch-ONR, CoBOP
Dave Phinney-ONR, CoBOP
Paul Falkowski-ONR, CoBOP

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http://nightsea.mit.edu/research/cobop/lsi/lsi.html